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EFFECTS OF POLYURETHANE SPONGE CLEANING ON CARRYING CAPACITY OF POTABLE WATER MAINS

1. Purpose. The purpose of this Public Works Technical Bulletin (PWTB) is to provide guidanc sponge cleaning of water mains. Procedures for cleaning mains are outlined, and observed result

2. Applicability. This information applies to all Army installations responsible for operation and r distribution systems.

3. References.

a. AR 420-46, Water Supply and Wastewater, 1 May 1992.

b. American Water Works Association. 1986. "Cleaning and Lining of Distribution System P CO.

c. Anderson, C. F., and Muller, G. 0. 1983. "Improving Raw Water Transmission Capacity a Transmission Costs by Polyurethane Pigging," American Water Works Association National Confe

d. Naval Energy and Environmental Support Activity. 1983 (Sep). "Potable Water Main Rehabilitation," NEESA 1-036, Port Hueneme, CA.

e. Walski, Thomas M. 1984. "Application of Procedures for Testing and Evaluating Water D Technical Report EL-84-5, U.S. Army Engineer Waterways Experiment Station, (WES) Vicksburg,

f. Walski, Thomas M. 1984. Analysis of Water Distribution Systems, Van Nostrand Reinhold

4. Discussion. The effects of tuberculation and scale formation on water main carrying capacity n chemical cleaning, sponge cleaning, or pipe replacement. This PWTB deals with the effects of pol cleaning ("pigging"). Pigging is a way of cleaning potable water mains which have accumulated tu their interior surfaces. Pigging is done by using a polyurethane sponge ("pig") inserted at one en The pig travels down the pipe propelled by the water pressure and debris is removed and pushed cleaning is an alternative to pipe replacement.

5. Point of Contact. Questions and/or comments regarding this subject, which can not be resolve MACOM level, should be directed to U.S. Army Center for Public Works , CECPW-ES, 7701 Teleg VA 22315-3862, at (703) 806-5194 or DSN 656-5194.

FOR THE DIRECTOR:

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Director of Engineering

EFFECTS OF POLYURETHANE SPONGE CLEANING ON CARRYING CAPACITY OF POTABLE WATER MAINS

1. Background.

a. Water Main Tuberculation and Aging. As water mains age, they continually accumulate tu their interior surfaces. In recent years, pipes have been made of polyvinyl chloride or lined with ce corrosion. However, before these materials were widely used, water mains were constructed of ur the rate of corrosion and tuberculation accelerated with time. A heavily tuberculated, unlined cast 1.

b. The Cleaning (Pigging) Process. Cleaning a water main with a polyurethane sponge ("pig simple. A pig is merely a flexible, bullet-shaped sponge. As shown in figure 2, pigs are available and have different densities and surfaces. Once the pipe to be cleaned has been isolated by clos pigs are inserted through a launcher, which is commonly a T- or Y-joint with a flange, as shown in propelled through the pipe by water pressure. As the pig progresses, it scrapes tuberculation or s Cleaning is also aided by a water jet around the body of the pig, caused by the difference of the in the exterior diameter of the pig. The pig travels the length of the pipe at approximately 95 percent exit (retrieving) point for the pig is a T- or Y-joint similar to the launcher except open to the atmosp pig reaches the retrieving point, it brings the removed scale and tuberculation with it. Debris remo discolored water (figure 5); therefore, all users should be valved off before the cleaning process b until water flushed through the main becomes sufficiently clear and free of solids. Generally, pigs surface roughness are used for each successive pass to promote gradual removal of debris and to within the pipe.

c. Fort Hood Facilities Technology Application Test (FTAT) Demonstration. Fort Hood, TX, w demonstration site for water main cleaning. A contractor pigged two 6-in. (15-cm) water mains wh characteristics of the lines were recorded. Procedures for cleaning mains are outlined, and obser

2. Data Collection.

a. Site Description. Figure 6 shows a schematic of the demonstration site. Both 6-in. (15-cm approximately 1,100 ft (335 m) long, 40 years old, and constructed of unlined cast iron. The lines are dead ends. The pig launcher was located at the intersection of the two 6-in. (15-cm) lines with main. The launcher was a T-joint installed in the 8-in. (20-cm) line. The valves on the 6-in. (15-cr the launcher allowed isolation of each pipe. Pig retrievers consisting of T-joints with approximatel and an elbow were installed in excavated pits at the end of each 6-in. line. The stand pipes and e water flow and debris out of the pits.

Figure 1. Heavily tuberculated unlined cast iron pipe.

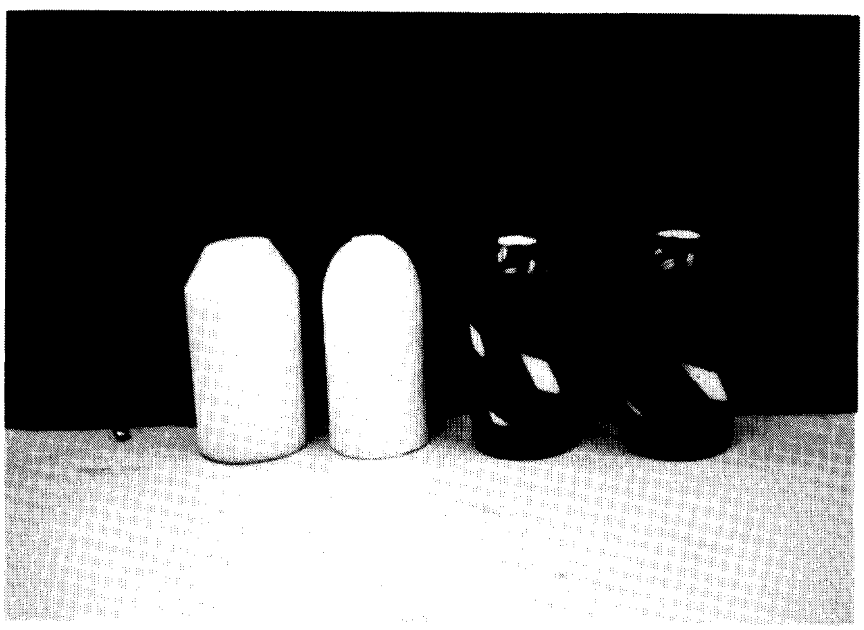


Figure 2. Types of pigs (left to right: swab, bare, crisscross, wire brush).

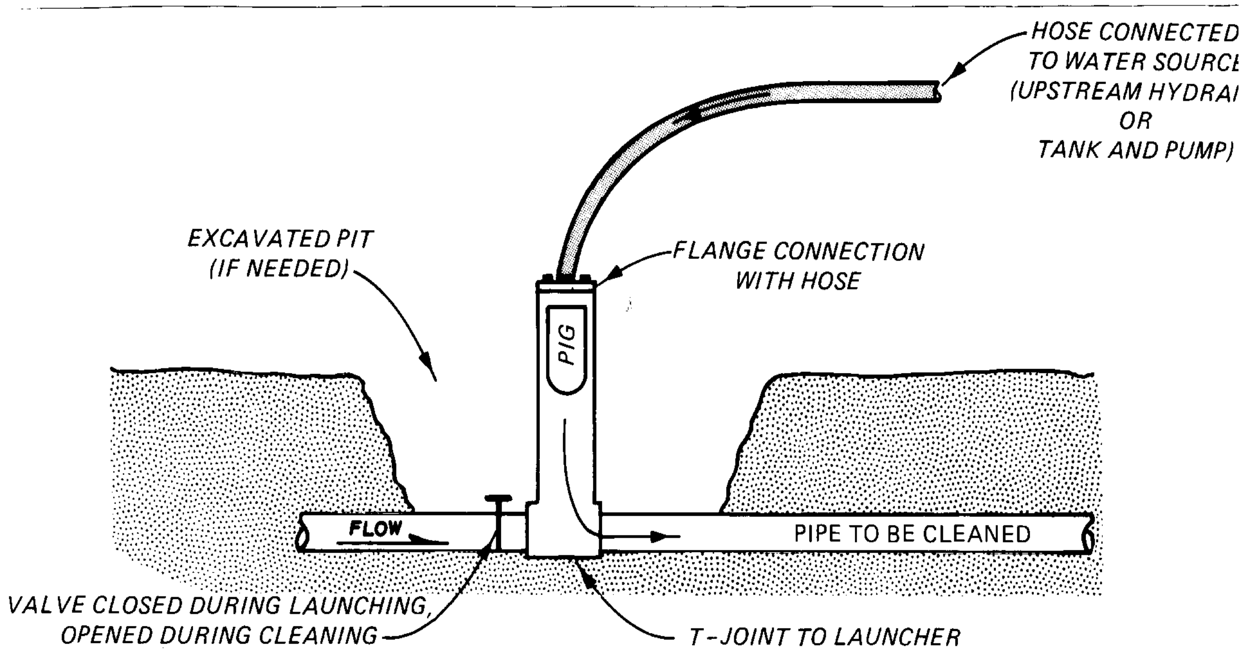


Figure 3. Typical pig launcher configuration.

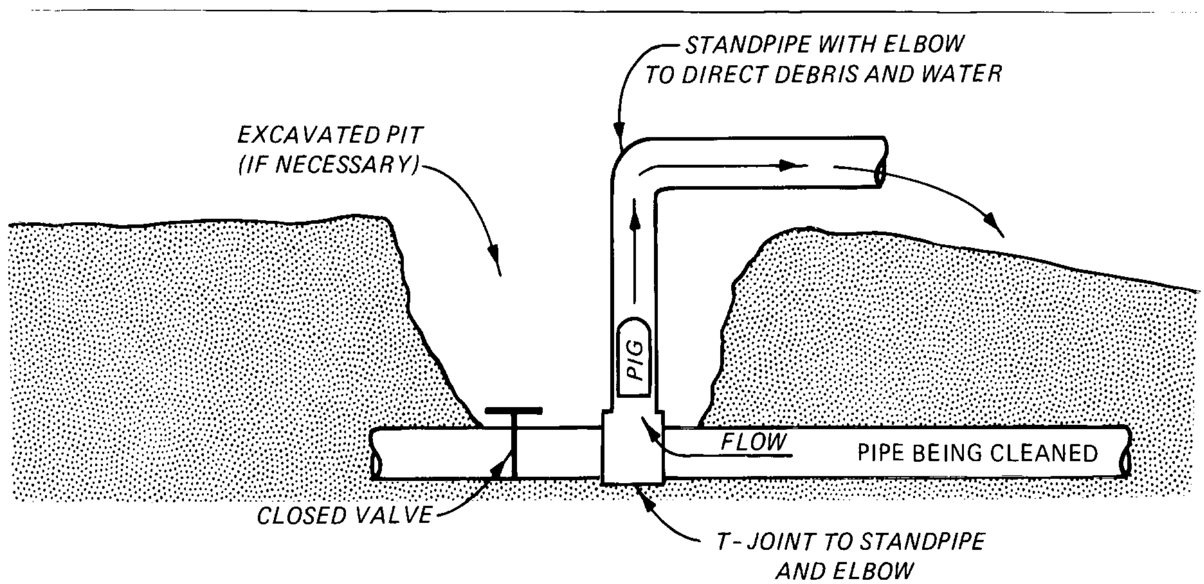


Figure 4. Typical pig retriever configuration.

Figure 5. Discolored water as a result of pigging.

b. Condition of Lines Before Cleaning. A visual inspection of 1-ft (0.3-m) segments of the 6-i removed at the pig launcher and retrieval sites revealed tuberculation as high as 0.4 in. (1 cm) co percent of the pipe wall. The Hazen Williams C-factor prior to cleaning was approximately 40 for a low value (a C-factor of 30 is extremely low and indicates a very rough pipe, while 140 is extrem smooth pipe), it is not uncommon for pipes of this age and material. The Hazen-Williams C-factor internal roughness of a pipe. Typically, C-factors range from 40 to 130, with 40 indicating extreme indicating new, smooth pipe. The C-factors were measured using the parallel hose described in T (see reference 3e). A C-factor measurement was not possible after each pass of the pig, as the p become stuck in the pipe because of debris jams at the retriever. A swab was often used for the f remove the pig and solids from the retriever.

c. Preparations for Cleaning and Testing.

(1) A primary consideration in preparing for cleaning is consumer notice. All water users ser cleaned must be valved off during the cleaning process. Otherwise, discolored water and debris v and can cause serious problems to domestic, commercial, and industrial users.

(2) Fittings such as elbows, T's, flanges, etc., must be installed, and the correct tools must be cleaning process. Excavation is usually necessary to install the joints where the pigs will be launc 6-in. pigs can sometimes be launched and retrieved through existing fire hydrants.

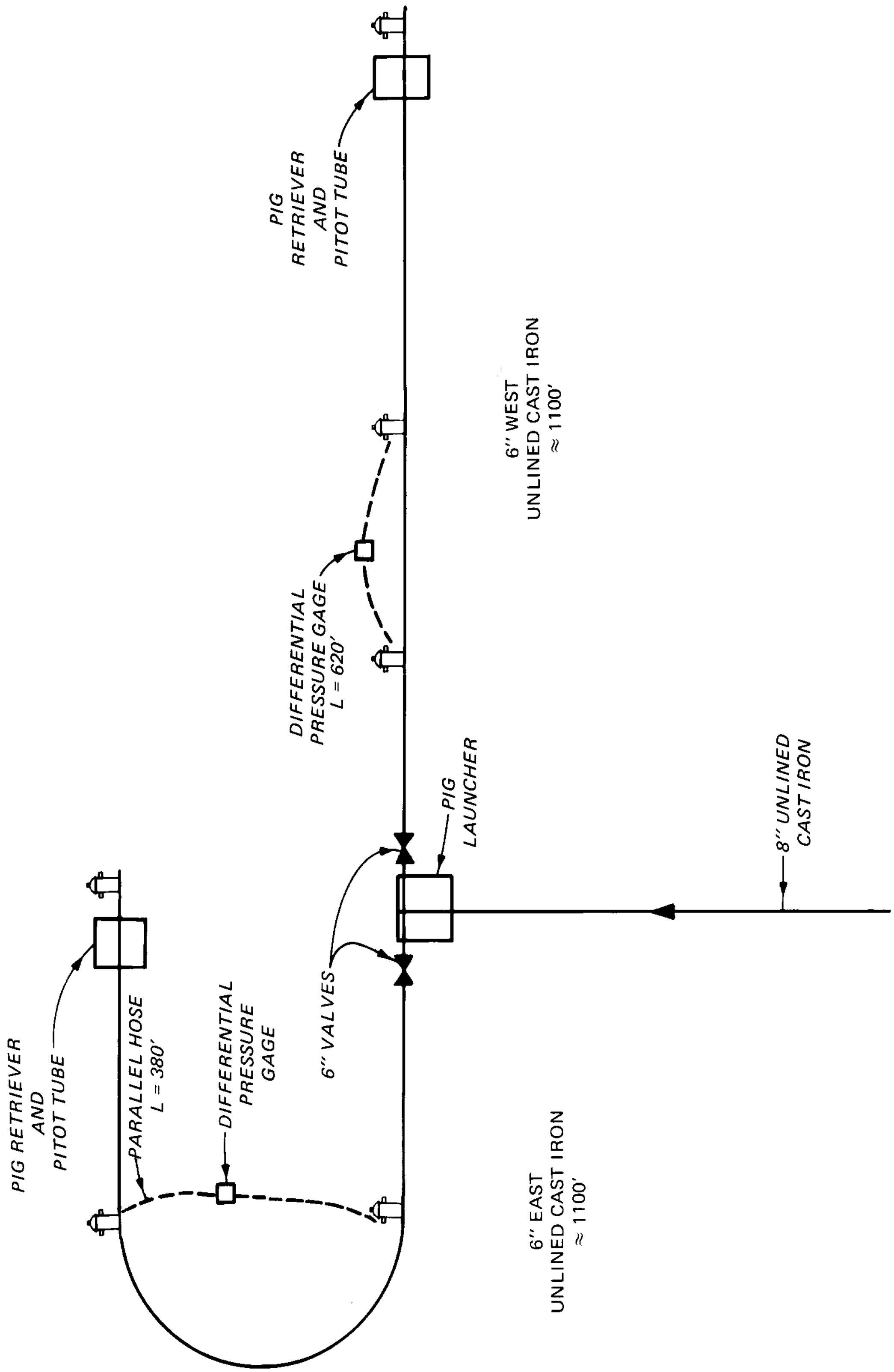
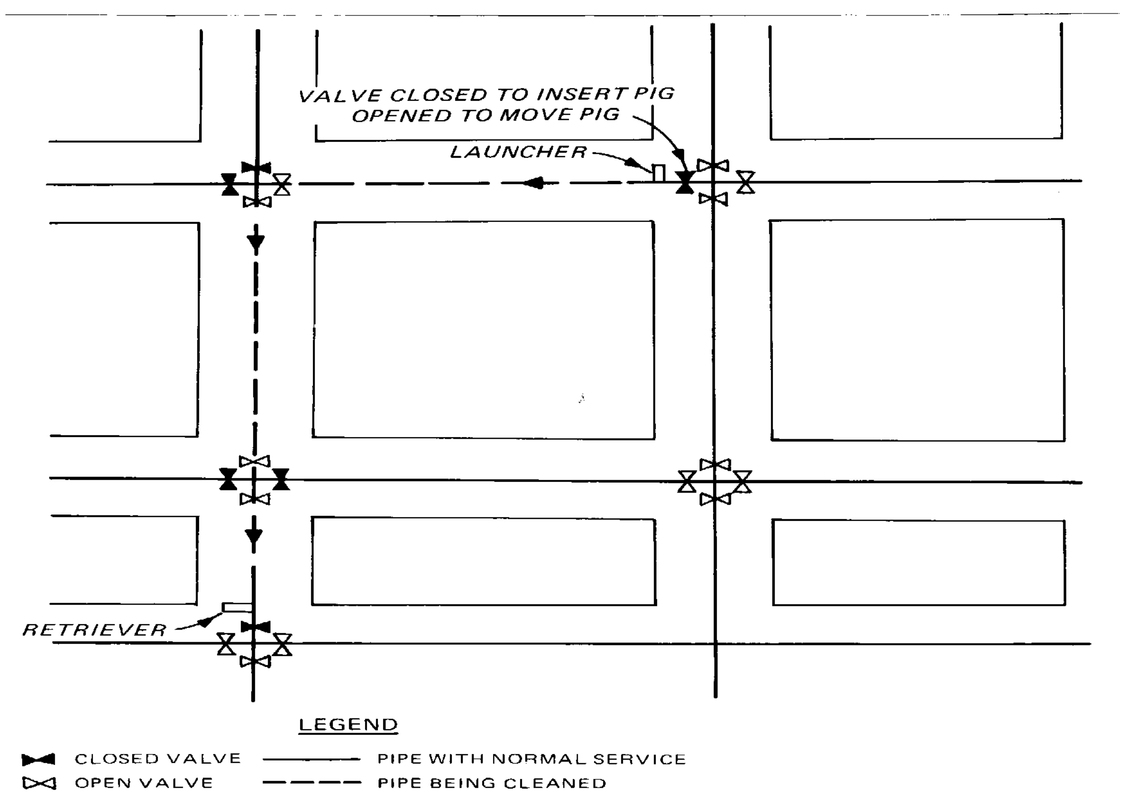


Figure 6. Fort Hood FTAT demonstration site.

(3) Proper planning of valve operation is essential to the cleaning process. The sectior be isolated by valving in order to install fittings. To insert the pig into the launcher, the pipe must l the valve must be operated again to propel the pig through the pipe with water pressure. This exe opening the valve must be repeated for each pass of the pig. Also, any valves along the cleaned | enable the pig to pass. A schematic of proper valving is shown in figure 7.

Figure 7. Typical valving plan for pigging.



(4) A pressurized water source is necessary for inserting the pig. Pig insertion can be connecting to an upstream hydrant with a backflow preventer in line, or a small water tank 250 gal nation. The pressurized water source will force the pig from the launching joint into the water mair can propel the pig through the line.

d. Line Swabbing, Cleaning, and Flushing.

(1) Under normal circumstances, the first pig passed through the line is a low-density ft) (16 to 32 kg/cu m) without any type of additional surface coating, called a swab (see figure 2,). deformed and torn when it is pushed against tough scale in the pipe. The swab is used mainly to and removes very little debris. A bare pig is then passed through the line. A bare pig is denser (2 240 kg/cu m) than a swab, but is still soft, noncoated, and highly deformable (figure 2). The smallest constriction within the pipe may be gaged by measuring the smallest diar retrieval. The amount of debris flushed out with the bare pig is an indicator of the extent of scale a

(2) After determining the smallest constriction within the pipe, a coated pig with a diameter ro smallest constriction was selected and passed through the line. Since the two 6-in. (15-cm) mains constrictions, 6-in. (15-cm) crisscross pigs were selected to follow the bare pig. The crisscross pig polyurethane coating and generally has a density similar to the bare pig (2 to 15 lb/cu ft), see figur crisscross pigs, a wire brush pig was used. A wire brush pig is coated with strips of wire mesh in a figure 2. Three to four passes were made using wire brush pigs until the amount of solids remove creased significantly. It is important to note that overcleaning, especially with the wire brush pig, c problems from scraping into the pipe wall and exposing corrosion cells that were previously covere Overcleaning should be avoided by closely watching the amount of solids removed.

(3) After the wire brush pigs had passed, a swab was run through the line to remove any rem total of 10 pigs were passed through each 6-in. (15-cm). (table 1)

Table 1
Pig Type Used with Pass of Pig

Pass	East Line Pig Type	West Line Pipe Type
1	Swab	Swab
2	Bare pig	Bare pig
3	Bare pig	Crisscross
4	Crisscross	Swab
5	Crisscross	Wire brush
6	Wire brush	Wire brush
7	Wire brush	Wire brush
8	Swab	Crisscross
9	Wire brush	Swab
10	Swab	Wire brush

e. Hydraulic Characteristics Versus Pigging Effort. Results of the hydraulic tests are present C-factors increased most during passes 2 through 6, with slower increases thereafter (see figures lines in figures 8 and 9 represent confidence bands based on a manual gage reading accuracy of head loss testing. They indicate upper and lower boundaries between which the actual C-factors did not increase significantly during the first two passes of the pig, as would be expected because used. Although 10 passes were made on each line, the C-factors reached approximately 95 perce the sixth pass. Figure 10 shows the C-factor versus pigging effort for both lines. Final C-factors f approximately 90. Based on the initial C-factors of approximately 40, the C-factors increased ove

f. Debris Samples and Measurements. Samples of the removed debris were taken during the The majority of the debris was removed with the crisscross and wire brush pigs. The debris was d but soft enough to break between the fingers. Chemical analyses were performed to determine ar composition (table 3). The remainder of the debris was composed primarily of oxygen in compour and iron oxide. The debris had a much higher iron than calcium concentration, verifying that the i corrosion more than scale formation.

g. Cost of Cleaning.

(1) Pipe cleaning is nearly always less expensive than replacement with new pipe. Cleanin economical with larger pipe diameters. The dividing line between large- and small-diameter pipes specific factors, such as excavation costs. If highways must be excavated, cleaning is almost alwa replacement for any size pipe. Reference 3c shows that cleaning can save an average of $7 (as c (30.48cm) of pipe when compared with replacement.

(2) It is highly recommended that water main cleaning be followed by internal lining. If pip tuberculation and scale can quickly reaccumulate and necessitate cleaning again within a few yea benefits permanent. Costs associated with cement or slip lining reduce the average savings to $4 (30.48cm) of pipe when compared with replacement costs (reference 3c).

3. Benefits of Cleaning.

a. Hydraulic Benefits. The most obvious benefit of cleaning is increased carrying capacity. T by over 100 percent, which means water can be supplied with less head loss.

b. Economic Benefits. As already discussed, cleaning is usually economically superior to rep major transmission mains are cleaned, the savings resulting from decreased pump head can decre horsepower requirements. This savings can be quite substantial for larger municipalities.

4. Questions and Answers. See appendix A for common questions and answers on pipe cleaning

Table 2

Results of Hydraulic Tests

Pass	East Line				West Line			
	Flow Rate (cfs)	Head Loss (ft)	f*	C-Factor	Flow Rate (cfs)	Head Loss (ft)	f*	C-Factor
1	0.48	18.4	0.252	37				Assumed 40
2	0.44	18.4	0.292	34				
3	0.56	16.2	0.169	45				
4	0.76	11.5	0.066	75	0.68	18.5	0.081	67
5	0.80	10.9	0.056	82	0.66	16.0	0.074	70
6	0.78	9.2	0.050	87	0.78	14.0	0.045	92
9	0.78	8.1	0.043	94				
10	0.75	8.1	0.048	89	0.71	11.5	0.045	91

* Darcy-Weisbach friction factor.

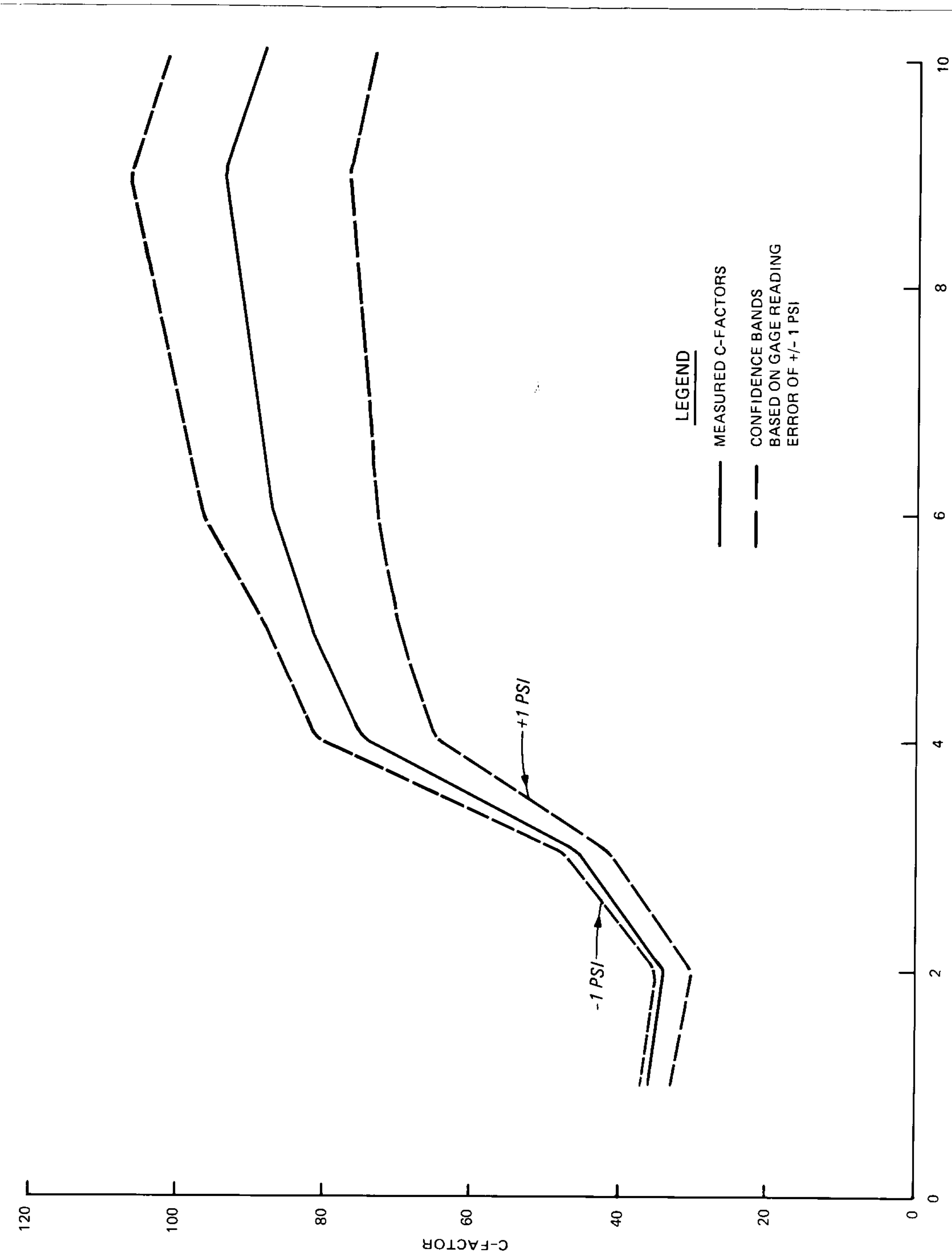


Figure 8. East line C-factor versus pass of pig.

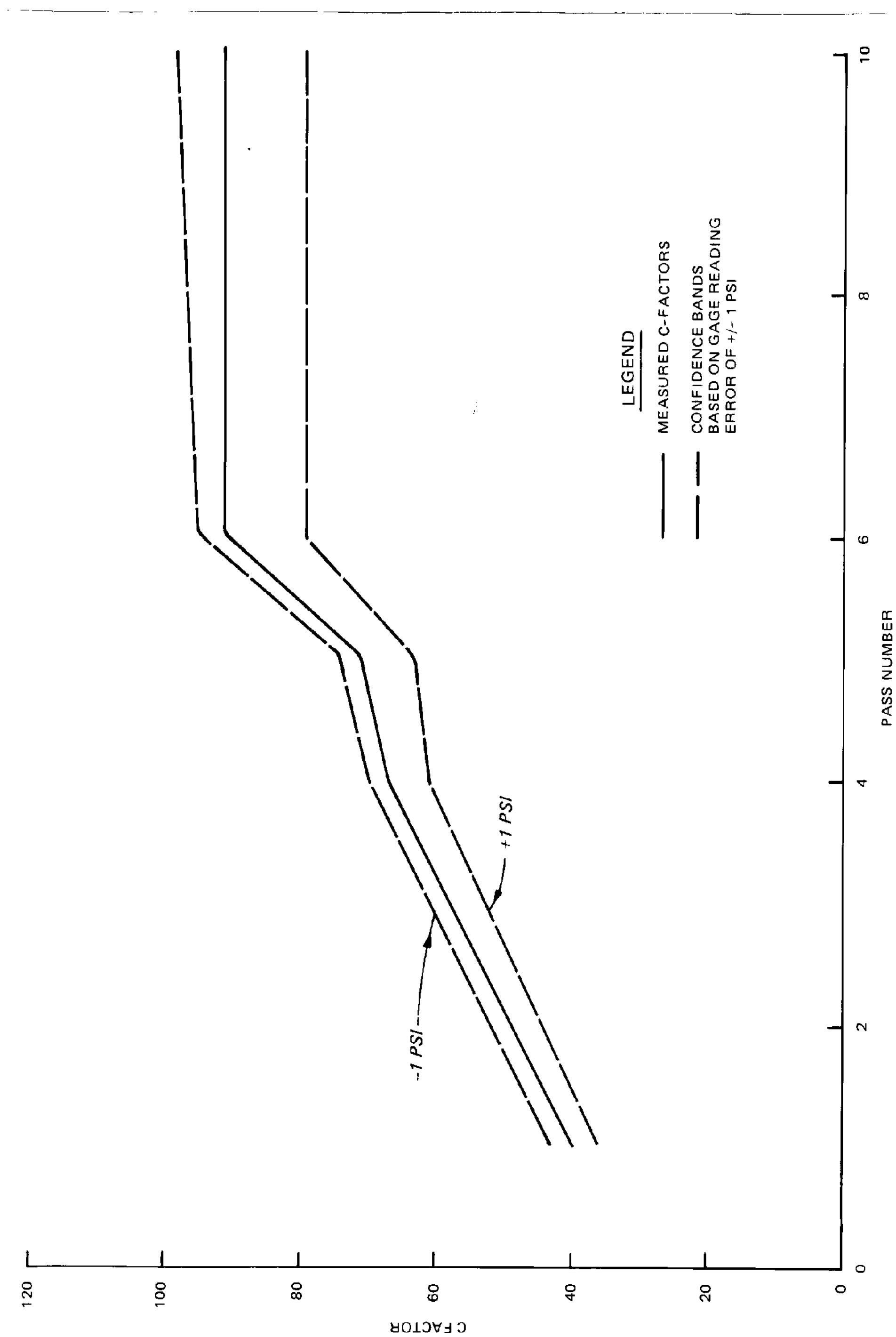


Figure 9. West line C-factor versus pass of pig.

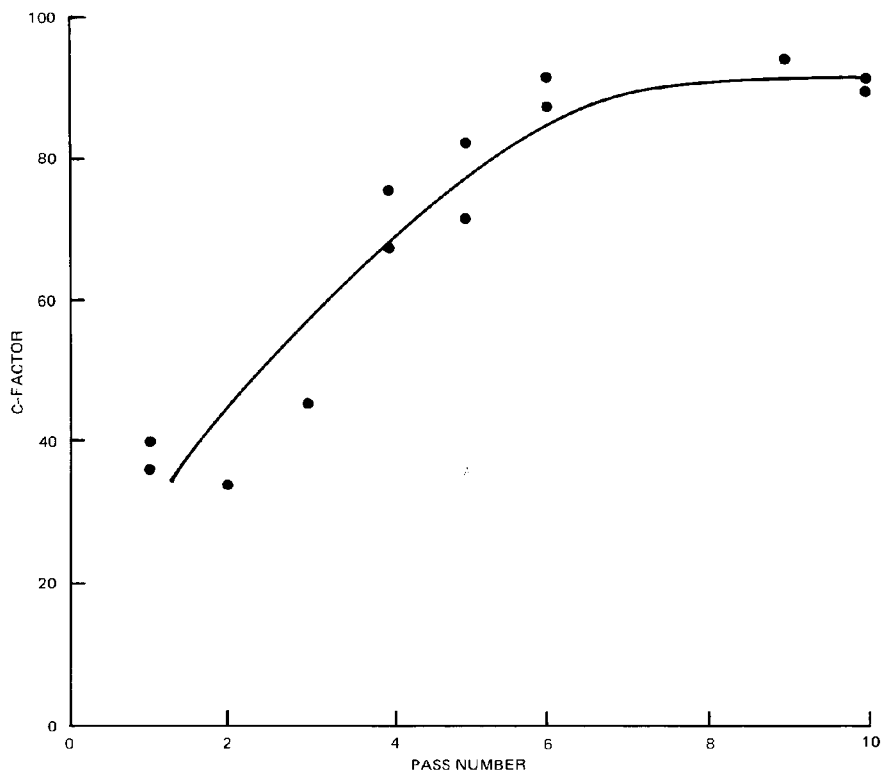


Figure 10. C-factor versus pigging effort (both lines).

Table 3

Results of Debris Composition Analysis

Chemical Constituent	Percent Concentration
Iron	45.0
Calcium	1.4
Aluminum	1.4
Chlorides	0.24
Total phosphorus	0.22
Magnesuim	0.21
Iron	0.04
Zinc	0.001
Lead	0.001

APPENDIX A

SHORT ANSWERS TO TYPICAL QUESTIONS ON PIPE CLEANING

Question	Short Answer
1. Is pipe cleaning less expensive than new pipes?	In most cases yes, especially for larger pipes. For sm pipes, replacement costs can be similar to cleaning co The dividing line between small and large pipes deper local excavation and construction conditions. In areas excavation for a new pipe is difficult, cleaning may be economical for even 6-in. (15-cm) pipes.
2. Is pipe cleaning a permanent solution?	Not unless the water utility does something to take aw source of the scale or tuberculation. This can be done treatment plant by pH adjustment or addition of corrosi and scale inhibitors. Tuberculation can also be prever cement mortar lining or sliplining of the pipe after clea
3. Is cement mortar lining economically justifiable?	Under most conditions, it is only economical for large-diameter pipes. The breakpoint here is between 16 in. (30 to 40 cm).
4. What should be done with the debris from a cleaning job?	Unless the pipe has been carrying hazardous material debris is clean and can be considered as clean fill. In some cases, it may be possible to discharge to a sa sewer or storm drain. Check with the appropriate loca environmental officials concerning disposal methods. states require an NPDES permit for discharging this tu water into a navigable water.
5. What C-factor can be expected in a pipe after cleaning?	Usually, values near 100 are possible for small (e.g., 6 15-cm) pipes. Higher values (near 120) can be obtain larger pipes.
6. Can polyvinyl chloride or asbestos cement pipes be pigged?	Pipe cleaning can remove scale from these pipes, but brush pigs should not be used.

7. What pipes should not be pigged?	Pipes with serious leakage or breakage problems. Th should be replaced. Pipes that, even after they are pi will have insufficient carrying capacity. These pipes s paralleled.
8. Will pipe cleaning reduce pumping energy costs?	Cleaning large pipes near a pumping station can redu energy costs. Cleaning small pipes far from pumping stations has negligible effect.
9. Should pipe cleaning be used to solve low-pressure or low-fire flow problems?	Only after it is determined that the problem is due to p conveyance caused by tuberculation and scale. First, eliminate other causes, such as inadvertently closed v undersized pipes. (Cleaning does not stretch pipes.) also desirable to visually inspect the inside of the pipe determine the nature of the deposits.
10. Does pipe cleaning cause red water problem?	Red water problems are caused by poor water quality. cleaning can make the problem worse by exposing ba metal. Therefore, a pipe should not be overcleaned. cleaning can actually remove debris and sediment fro more effectively than flushing.
11. Can a pig pass through bends and tees?	Yes.
12. How do you steer a pig through a cross or tee?	By closing all downstream valves in the cross or tee e the one in the direction you want the pig to travel.
13. What can be done before the pipe cleaning operation to minimize problems?	A few weeks before the project, identify all of the valve must be operated to steer the pig through the system. test every valve by operating it. Replace or repair any that will not work. Prior to cleaning, it is also helpful to all customers.

14. Can a computer model of a pipe network help to decide which pipes need to be pigged?	By using a calibrated computer model, an engineer ca determine which portions of the distribution system ha inadequate carrying capacity. The engineer can simu system with and without cleaning to determine if clean sufficiently increase the carrying capacity to meet fire- pressure requirements. The WADISO computer progr (Engineer Manual 1110-2-5022, chapter 28) can calcu costs as well as flows and pressures to simplify the an
15. Can any contractor do pipe cleaning work?	Experience is very important in successful pipe cleani to find a contractor who has successfully completed pi cleaning projects before. Check references if possible
16. Is there a minimum-size project below which cleaning is uneconomical?	Because of mobilization costs, it is best to clean sever thousand feet in a single contract.
17. Can pigs travel several thousand feet?	Yes, but it is best to break a project down into runs of hundred to a thousand feet. Otherwise, the pig can be stopped by the debris that accumulates in front of it.
18. If there are several pipes in parallel and only one needs to be cleaned, which one should be selected?	The one with the fewest service connections and the r convenient location for catching and removing debris.
19. Is there a C-factor below which cleaning becomes justified?	It depends on the situation. Some pipes are sufficient in comparison with demands and will work with a C-fac 30. Some pipes may experience problems with a C-fa 80. The key to decision-making is whether the pipe w function properly after the project. A computer model pipe network can be used to determine this.